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ABSTRACT

The effect of special instruction in certain reading skills involved in solving verbal problems was compared with the effect of supervised practice in solving verbal problems on the improvement of verbal problem-solving ability of 179 fourth graders. The sample from six classes in three public elementary schools in Cuyahoga Falls, Ohio, was divided into two groups. The special instruction treatment group received 18 lessons of instruction in reading verbal problems, and the supervised study group solved verbal problems using whatever method they wished. Children in both groups improved significantly from pretest to post-test on the investigator-designed Verbal Problems Test. However, neither group resulted in significantly higher mean scores on the post-test. The girls in the special instruction group made significantly higher mean scores on the reading subtest of the post-test than did the boys in that group. No other significant differences were found between treatments, between sexes within treatments, or between sexes differentiated by treatments. The Stanford Achievement Test Reading and Mathematics subtests were also administered. Neither specific reading abilities, general reading abilities, nor computational abilities were found to be more highly correlated with verbal problem solving. References, tables, sample test items, and worksheets are included. (CL)

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IMPROVING MATHEMATICS VERBAL PROBLEM SOLVING ABILITY THROUGH READING INSTRUCTION

One of the difficult areas in mathematics for elementary school children has been working with verbal problems. Even though they may be able to do the computational work in mathematics, children find solving verbal problems most arduous. Researchers have listed various factors which influence success in verbal problem solving (2), (3), (4), (15). Although there is lack of agreement on certain factors, there is consensus that children must be able to recognize words and comprehend thought units in the problem, logically interpret the problem situation, and organize the information in such a way as to lead to an answer to the stated question. Computation skill is also necessary in solving verbal problems but is useless without the ability to read the problem accurately.

Reading to solve a verbal problem involves a composite of several reading skills which differ somewhat from those used to read narrative-type materials. Authorities believe that these reading skills are best learned within the con-

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RE002 941

text in which they are to be applied, rather than through instruction given during the developmental reading period (5), (6), (7), (9), (10), (11), (13). Numerous suggestions for improving children's ability to solve verbal problems have been given by authorities in both the fields of reading and mathematics (1), (8), (12), (14).

Reading Mathematics Materials

In mathematics literature, the style of writing is quite different from that usually found in narrative-type materials. Only short units of material are read at one time. In place of ten to fifteen or more pages which might be read for an assignment in social studies, science, or a developmental reading lesson, no more than one or two pages are usually read per day in mathematics. There is little continuity between paragraphs. Each verbal problem may be completely unrelated in content to the previous one. The content of verbal problems is usually of little importance, only a means to an end, to interest the child in working the problem.

Mathematics writing is compact, with each word being important. Content is limited to essential ideas. The lack of rich context makes word identification difficult. The vocabulary in mathematics literature presents a stumbling-block to many children. Some of the words may already be familiar but have unfamiliar meanings in mathematics context. Others are easily identified as belonging only to the field of mathematics and are seldom met in narrative-type reading.

Each of these types of technical vocabulary must be recognized and the concepts carefully taught if children are to understand what they read in mathematics.

A mixture of graphic and numerical symbols may break the reader's train of thought and prevent him from reading in complete thought units. The reader needs as good an understanding of the numerals, signs, and abbreviations used in mathematical writing as he would have if these concepts were all expressed in the uneconomical form of words. The reader tends to concentrate on the numerals in a problem since he knows they will be needed for its solution. Terry found that different patterns of eye-fixations were required for reading words and reading numerals, the adjustment causing difficulty for some children.

Reading verbal problems requires more intense concentration than that needed for reading narrative-type materials. Time must be taken periodically to reflect upon what has been read, to search for relations between the information given, and to apply appropriate mathematical skills for the solution of the problem. Analytical reading is necessary for recognizing limitations of the data given, determining relevancy of information, and recognizing relations. The reader must then be able to synthesize or integrate his ideas and infer the appropriate operation to be used in solving the problem. This type of reading is necessarily slower than that used for reading narrative-type materials. A common belief is that the slow reader has the advantage in read-

ing mathematics materials. Eagle, found, however, that the slow readers were less successful in mathematics than the average or fast readers who read carefully and with precision. He concluded that "perhaps one of the most helpful things teachers can do in this connection is to help students learn to adapt their rate of reading to the type of material being read and to the purpose they have in mind in reading it."

Rereading is often unnecessary in reading narrative-type materials but is essential for successful reading of verbal problems. A quick skimming of the problem will enable the reader to get a general impression of the problematic situation to determine the main idea. He should be able to recognize what is required in the problem, i.e., what the question is. This must be held in mind as he rereads the problem to pick out the relevant details, to see the relations between the main and subordinate ideas, to organize the data, and to infer a process for solving the problem. After the computation is completed, another rereading is necessary to check the reasonableness of the answer. These rereadings are each for a different purpose and require different reading skills. Children must become aware of these differences and adjust the type of reading involved in each particular reading of the problem.

Purpose of the Study

On the basis of some of the suggestions and the findings of previous research, this study was designed to test the effect of special instruction in certain reading skills involved in solving verbal problems on the improvement of children's ability to solve verbal problems. Two minor hypotheses concerned the relationship of specific reading abilities, general reading ability, and computation ability to problem solving ability.

Girls are usually more proficient in language skills than are boys. Assuming the importance of reading ability to success in solving verbal problems, it seemed probable that girls would receive higher scores on tests of ability to solve verbal problems than would boys. Scores made on tests of verbal problem solving ability by boys were compared to those made by girls to discover if significant differences existed.

Materials and Procedures

Evaluation Instruments

The Verbal Problems Test, designed by the investigator to measure children's ability to use certain reading skills in reading verbal problems, was composed of three subtests:
(1) Reading Subtest -- thirty verbal problems followed by multiple-choice questions testing comprehension of the problems (a sample of these items may be found on page 25);
(2) Solving Subtest -- the same thirty verbal problems used

in the Reading Subtest followed by space for solving the problems; and (3) Computation Subtest -- the computation examples only (no verbal problems) which would be expected to be used in the solution of the problems in the Solving Subtest. The third subtest was included as a check measure, i.e., if a child was able to work a particular computation example but was unable to solve the corresponding verbal problem, a reading difficulty might be implied.

The reading skills measured by the Verbal Problems Test include recognizing and understanding vocabulary, determining the main idea, visualization, relating the situation in the problem to one's own experiences, recognizing what is being asked, deciding which given information is necessary for solution of the problem and which is irrelevant to the solution, recognizing when the information given is insufficient for a solution, inferring the mathematical operation which is appropriate for relating essential information and solving the problem, determining the appropriate sequence of operations when several steps are necessary for a solution, and interpreting the result of completed computation in terms of the question stated in the problem.

The Verbal Problems Test was given on three consecutive days to the subjects of this study, both as a pre- and post-test. Intelligence quotients from the California Test of Mental Maturity, administered to the children in third grade, were recorded for use in the analyses. The Stanford Achieve-

ment Reading and Mathematics tests were used to assess beginning reading and problem solving ability. The Stanford Achievement Mathematics Test was also used as a posttest.

Sample

Fourth grade children from six classrooms in three elementary schools of the public school system in Cuyahoga Falls, Ohio, were selected as subjects for this study. The children represented various socioeconomic levels and a range of intelligence (I.Q.'s ranging from 75 to 150). The 179 children were assigned to one of two treatment groups (special instruction group, and supervised study group) according to scores made on the pretest of the Verbal Problems Test, using a method which provided two groups differing very little in initial ability to solve verbal problems. (Table 1, page 8) Half of the children in each classroom were in each treatment group. Children in all levels of verbal problem solving ability were in both groups, but the mean scores of both groups were not very different. The groups were also found to be not very different in chronological age, I.Q., reading achievement, and mathematics achievement as measured by standardized tests. (Table 2, page 9)

Lessons

The lessons for the two treatment groups were taught in addition to the regular reading and mathematics instruction given each day by the classroom teachers. The children

Table 1

Raw Score Means and Standard Deviations for Each of the Treatment Groups on the Pretest of the Verbal Problems Test

Test	Special Instruction (N=88)		Supervised Study (N=91)	
	Mean	S.D.	Mean	S.D.
VPT-Reading	13.74	4.40	14.01	4.87
VPT-Solving	10.43	4.61	10.36	4.52
VPT-Computation	16.92	3.96	17.17	3.91
VPT-Total Test	41.07	11.16	41.54	11.15

Table 2

Means and Standard Deviations on Pretest Measures of C.A., I.Q., Reading Achievement, and Verbal Problem Solving Ability for Each Treatment

Pretest Measures	Special Instruction (N=88)		Supervised Study (N=91)	
	Mean	S.D.	Mean	S.D.
C.A. (mos.)	117.24	6.08	116.95	6.43
I.Q.	111.94	12.31	113.30	14.52
S.M.G.	3.59	1.08	3.63	1.01
Stan. Ach. Reading WM	4.60	1.17	4.57	1.17
Stan Ach. Reading PM	4.18	1.21	4.27	1.32
Stan Ach. Reading Ave.	4.40	1.14	4.45	1.18
Stan Ach. Math. ACm	3.67	0.54	3.65	0.64
Stan. Ach. Math. AA	4.40	1.02	4.49	0.92
Stan. Ach. Math Ave.	4.06	0.67	4.10	0.65

Note.--Grade equivalent scores were used for each of the Stanford Achievement Tests.

in the special instruction group in both classrooms in a school met together for instruction, as did the children in the supervised study group from both classrooms. The investigator taught both groups in order to control the teacher variable as much as possible and to insure that the lessons were similar in all three schools. The treatment groups met on alternate days. Each group in each school received eighteen one-half hour lessons during a nine-week period, making a total of about ten hours' instruction.

The purpose of the instruction given to the children in the special instruction group was to strengthen their ability to read verbal problems. The lessons stressed skills of recognizing and understanding vocabulary, selecting the main idea, recognizing the question asked in the problem, noting important details which must be used in solving the problem, noting when information was insufficient for a solution to be reached, noting when the problem contained information not relevant to the solution of the problem, organizing the information given and recognizing relations which existed in view of the question asked, reading to note sequence, predicting outcomes, and formulating a sentence which answered the question in the problem. No computation, either written or oral, was required in these lessons; all instruction involved reading the problems.

The problems used for these lessons were organized so that each lesson was somewhat more complex than the preceding lessons, even though the basic plan of the lesson might be

similar. Each lesson's problems required the use of all previously taught reading skills, reinforcing previous learnings while introducing a new skill to be learned. In general, the plan of a lesson involved a teacher-directed discussion of three or four verbal problems. During this discussion, the children were helped to become aware of the particular idea or skill being emphasized through that lesson. The children used a worksheet as a guide while working problems. The worksheet contained the headings of vocabulary, main idea, question, important facts, relation sentence, mathematical sentence, and answer sentence, as well as space for writing the appropriate information under each heading.

Two examples of these worksheets as completed by children are given on pages 26 and 27. To find the main idea of the problem, the child was encouraged to read the problem quickly, skimming to get a general picture of what the problem was about. The question in the problem was noted and written in the appropriate place. Symbols were used to represent the question, and the important facts which were necessary for the solution of the problem, in order to reduce the task of expressing the relation sentence with words. Reading the symbols by the use of words was stressed, however, in order to assure the children had their meaning well in mind. After the relation sentence was written, each important fact was related back to the situation in the verbal problem, and the numeral selected which could be used to replace that fact, thus building the mathematical sentence through direct

relation to the structure of the problem situation already delineated. The replacement for the symbol representing the answer to the question could be found through the appropriate mathematical computation, although this was not completed during the lessons of this treatment. The answer sentence, then, contains the numeral found by computation, and is expressed as a transformation of the question originally posed in the problem.

The supervised study group was given a series of lessons during which they solved verbal problems, using any method they wished. No instruction was given during this time, although whatever questions children had while solving the problems were answered except those concerning choice of operation. The purpose of this treatment was to control the amount of time spent on mathematics, giving children in both groups equivalent time in some type of work with verbal problems.

Analysis of Data

Intercorrelations among all variables were examined to discover significant relationships. Those variables correlating most highly with the criterion measure (the Verbal Problems Posttest) were used in a multiple correlation analysis to determine the most powerful predictors of success on the criterion measure. These predictors were then used as covariates with the criterion measure in an analysis of covariance. Comparisons were made by treatments, by sex

within treatments, and by sex differentiated by treatments. The .05 level was considered the point of statistical significance, and all tests of significance were two-tailed.

The major purpose of this study was to find out whether special instruction in specific reading skills applied in solving verbal problems would improve children's ability to solve problems more than opportunity to practice solving many problems. Correlated t-test analyses of comparisons of pre- and posttest mean scores in both treatment groups indicated positive changes in scores on all subtests and the total test for both treatment groups at the .01 level. (Table 3, page 14) However, differences according to the covariance analysis of mean scores on the Verbal Problems Posttest made by children in the two treatment groups were not statistically significant ($p > .05$). (Table 4, page 15) Neither the special instruction group nor the supervised study group made higher mean scores on the total test or any of the subtests.

Two minor hypotheses concerned the relationship of specific reading abilities, general reading ability, and computation ability to problem solving ability. Differences between the correlation coefficients for the Reading and Solving subtests (.581 and .631) and for the Computation and Solving subtests (.633 and .650) of the Verbal Problems Test, using both pre- and posttest correlations, were tested for significance. Differences between the correlation coefficients for the Verbal Problems Test Reading and Solving

Table 3

Actual Pre- and Posttest means and Gain on the Verbal Problems Test for Each Treatment Group

Test	Special Instruction (N = 88)			Supervised Study (N = 91)		
	Pretest Means	Posttest Means	Gain	Pretest Means	Posttest Means	Gain
VPT-Reading	13.74	16.32	2.58	14.01	15.95	1.94
VPT-Solving	10.43	13.77	3.34	10.36	14.91	4.55
VPT-Computation	16.92	19.14	2.22	17.17	19.90	2.73
VPT-Total Test	41.07	49.23	8.16	41.54	50.76	9.22

Note.--Correlated t-test analyses of comparisons of pre- and posttest scores in both treatment groups indicated positive changes in scores on all subtests and the total test for both treatment groups at the .01 level.

Table 4

The Significance of Differences of Verbal Problems Posttest Means for Treatment Groups

Test	Adj. Means SI[a]	Adj. Means SS[b]	Adj. MS	F-Ratio
VPT-Reading	16.50	15.77	24.107	1.747
VPT-Solving	13.98	14.71	13.798	1.674
VPT-Computation	19.28	19.76	10.497 7.810	1.344
VPT-Total Test	49.75	50.25	11.183 42.736	0.262

Note.--For df = 1,174, F's of 3.90 and 6.81 are significant at the .05 and.01 levels, respectively.

[a]Special instruction group (N = 88)

[b]Supervised study group (N = 91)

subtests (.581 and .631) and for the Stanford Achievement Reading Test and the Verbal Problems Test Solving subtest (.607 and .636), using both pre- and posttest correlations, were also tested. The t-test results indicated no significant differences between any of the correlations compared.

Since solving verbal problems involves both reading and mathematics skills, and since some previous research has indicated that girls excel boys in reading while boys excel girls in mathematics, it seemed worthwhile to examine differences between mean scores made by boys and girls.

A covariance analysis of mean scores made on the Verbal Problems Posttest by girls and boys within each treatment group revealed that girls in the special instruction group made significantly higher mean scores ($p < .05$) than the boys in this group on the Reading subtest of the Verbal Problems Test. (Table 5, page 17) The Scheffé test of comparisons of means following an F test substantiated this difference, yielding an F of 5.297 ($p < .05$). This finding also supports the significant negative correlation of sex with the posttest of the Verbal Problems Test Reading subtest which indicated the superior performance of girls in the special instruction group on this subtest.

The covariance analysis of mean scores of the Verbal Problems Posttest made by boys and girls differentiated by treatment groups indicated no significant differences ($p > .05$) between boys in either treatment group or between girls in either treatment group on any of the subtests or

Table 5

The Significance of Differences of Verbal Problems Posttest Means for the Special Instruction Group Differentiated by Sex

Test	Adj. Means			
	Girls (N=47)	Boys (N=41)	Adj. MS	F-Ratio
VPT-Reading	17.23	15.27	82.113 15.880	5.171
VPT-Solving	13.97	13.55	3.738 15.347	0.244
VPT-Computation	19.38	18.86	5.927 7.711	0.769
VPT-Total Test	50.51	47.76	162.392 42.782	3.796

Note.--For df = 1,86, F's of 3.96 and 6.96 are significant at the.05 and .01 levels, respectively.

on the total test. (Tables 6, 7, and 8, pages 19, 20, and 21)

Discussion and Implications

Although the results of this study revealed no significant differences between scores made by children who received instruction in reading verbal problems and those who received opportunity to practice solving many verbal problems, reading instruction in the context of verbal problems did improve children's ability to solve verbal problems but was no more effective than supervised study in solving verbal problems. The question must be raised whether or not another group of children receiving neither treatment might have made similar improvement during a similar period of time. It may be that whatever improvement in verbal problem solving ability occurred during the time of this study was a result of the regular classroom instruction and not due to either treatment. Since no "control" group was involved in the design of this study, it is not possible to determine whether or not this may have occurred.

The only significant difference found between treatments was in favor of the girls in the special instruction group who made higher mean scores ($p < .05$) on the Reading subtest of the Verbal Problems Posttest than did the boys in that group. The special instruction was apparently more powerful for girls than for boys in improving verbal problem solving ability. Since girls are generally more proficient

Table 6

The Significance of Differences of Verbal Problems Posttest Means for the Supervised Study Group Differentiated by Sex

Test	Adj. Means			
	Girls (N=44)	Boys (N=47)	Adj. MS	F-Ratio
VPT-Reading	16.51	15.42	25.033 11.265	2.222
VPT-Solving	14.60	15.21	8.333 13.677	0.609
VPT-Computation	19.62	20.16	6.719 7.391	0.909
VPT-Total Test	50.44	51.06	8.668 41.458	0.209

Note.--For df = 1.83, F's of 3.96 and 6.96 are significant at the .05 and .01 levels, respectively.

Table 7

The Significance of Differences of Verbal Problems Post-test Means for Girls Differentiated by Treatment

Test	Adj. Means		Adj. MS	F-Ratio
	SI[a]	SS[b]		
VPT Reading	17.81	16.84	21.481 12.385	1.734
VPT Solving	14.79	14.98	0.853 11.976	0.071
VPT Computation	19.70	19.68	0.015 5.813	0.003
VPT Total Test	52.37	51.42	20.518 36.637	0.560

Note.--For df = 1,86, F's of 3.96 and 6.96 are significant at the .05 and .01 levels, respectively.

[a]Special instruction group (N = 47)

[b]Supervised study group (N = 44)

Table 8

The Significance of Differences of Verbal Problems Post-test Means for Boys Differentiated by Treatment

Test	Adj. Means		Adj. MS	F-Ratio
	SI[a]	SS[b]		
VPT-Reading	15.09	14.69	3.461 14.010	0.247
VPT-Solving	13.13	14.40	34.536 17.006	2.031
VPT-Computation	18.79	19.84	24.105 9.981	2.415
VPT-Total Test	46.91	49.01	95.056 48.542	1.958

Note.--For df = 1,83, F's of 3.96 and 6.96 are significant at the .05 and .01 levels, respectively.

[a]Special instruction group (N = 41)

[b]Supervised study group (N = 47)

in language skills, they may have been more ready to learn the skills and apply them in solving verbal problems.

Since scores made on tests of reading ability and computation ability correlated highly with scores made on tests of verbal problem solving ability but neither yielded a significantly higher correlation, it would seem that both abilities are essential for successful problem solving. The type of instruction given to a child might best be planned according to his weaknesses in solving verbal problems. If a child is able to do the expected mathematical computation but still has difficulty with verbal problems, the cause might lie in his inability to apply the necessary reading skills in the analysis of the problem. In such a case, concentrated work on reading verbal problems might improve his problem solving ability. If a child is able to select the correct operation and numbers to be used in solving a verbal problem but arrives at an incorrect solution, practice for mastery of the mathematical skills involved would be appropriate. A combined approach may be required for some children, if weaknesses are evident in both mathematical and reading skills.

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SAMPLE ITEMS FROM THE VERBAL PROBLEMS TEST

1) Janet had 7 jacks. Then Ann gave her 9 more. How many jacks does Janet have now?

This problem is about
A) something to eat
B) something girls play with.
C) some animals
D) Something needed in school.

2) Mrs. Adams bought a package of notebook paper for her three children to use at school. There were 15 sheets in the package. It cost 25¢. If the children shared the paper equally, how many sheets did each child get?

To work this problem I need to know
A) what the paper would be used for.
B) how many sheets of paper the three children has to share.
C) how much the whole package of paper cost.
D) how much each sheet of paper cost.

3) Brad had $3.00 when he went to the store. He paid $1.98 for a puzzle, and 59¢ for a box of 12 crayons. How much more did he pay for the one thing that he bought than the other?

This problem asks me to
A) find how much change Brad will receive.
B) find the cost of two things.
C) compare the prices of two things.
D) find how much each crayon costs.

4) Jerry's class is making a calendar, and will use a separate sheet of paper for each month of the year. If each child makes one calendar, how many pieces of paper will be needed for the whole class to make their calendars?

To work this problem I do NOT need to know
A) how many months are in a year.
B) how big the sheets of paper are.
C) how many children are going to make calendars.
D) how many months will be put on each sheet.

SAMPLE WORKSHEET

Mrs. Blue serves bacon three mornings a week. There are 5 members in the family and each one has 3 slices of bacon each time it is served. How much bacon does each person eat in a week?

Main idea:

A family eats bacon for breakfast.

Question:

□ = how many pieces of bacon one person eats in a week

Important facts:

△ =the number of times bacon is served in one week
▽ =how many slices one person eats each time it is served

Relation sentence: (words)

The number of times bacon is served in one week times the number of slices one person eats each time it is served equals the number of pieces one person eats in a week.

Relation sentence: (symbols)

△ x ▽ = □

Mathematical sentence:

3 x 3 = □ □ =9

Answer sentence:

Each person eats 9 pieces of bacon each week.

SAMPLE WORKSHEET

Ellen scored 86, 93, and 74 on three tests. What is the difference between her highest and lowest scores? What is the sum of her scores for the three tests?

Main idea:

Ellen's test scores are given.

Question:

□ = the difference between highest and lowest scores
◇ = the sum of all three scores

Important facts:

▽ = the score on one test
▭ = the score on a second test
△ = the score on a third test

Relation sentence: (words)

The highest score minus the lowest score equals the difference between her highest and lowest scores.

The score on one test plus the score on a second test plus a score on a third test equals the sum of all three scores.

Relation sentence: (symbols)

▭ − △ = □
▽ + ▭ + △ = ◇

Mathematical sentence:

93 − 74 = □ □ = 19

86 + 93 + 74 = ◇ ◇ = 253

Answer sentence:

The difference between the highest and lowest scores is 19.

The sum of all three test scores is 253.